



Docket No. 227 - Serial No. 10/077,569
Filed: 02/15/2002 - Art Unit 1746
Examiner: Monique M. Wills

February 15, 2005

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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Matter of the Application of:

Chun Hua Chen, Yoo-Eup Hyung,
Donald R. Vissers and Khalil Amine

APPLICANTS' BRIEF ON APPEAL

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BEFORE THE BOARD OF PATENT

APPEALS AND INTERFERENCES

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of : Chun-hua Chen et al.
Title : LITHIUM ION BATTERY WITH IMPROVED SAFETY
Serial No. : 10/077,569
Filing Date : February 15, 2002
Art Unit : 1746
Examiner : Monique M. Wills

I. REAL PARTY IN INTEREST:

The University of Chicago, an Illinois Corporation, as assignee of the subject matter of the application is the real party in interest.

II. RELATED APPEALS AND INTERFERENCES:

Related Appeals and Interferences: There are no related appeals or interferences.

III. STATUS OF CLAIMS:

Claims 1-32 are pending in the application. Claims 1-8, 11-23 and 26-32 are rejected. Claims 9, 10, 24 and 25 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

IV. STATUS OF AMENDMENTS

Amendment A was filed in this case July 15, 2004 amending claims 1-15, 17-21 and 23-29. Claims 16, 22 and 30-32 were unchanged. A final Office Action dated September 23, 2004 finally rejected claims 1-8, 11-23 and 26-32.

V. SUMMARY OF CLAIMED SUBJECT MATTER

This invention relates to non-aqueous rechargeable lithium batteries and to additives primarily for improving the safety thereof. It particularly pertains to the use of a blend of additives such as phosphate compound additives and organic carbonates, as well as single additives as a means for rendering lithium ion batteries safe from overcharge, over discharge or abuse testing.

This invention pertains to lithium batteries or cells of the type set forth in which the anode or negative electrode includes or consists of a crystalline graphite or lithium metal or lithium alloy and an electrolyte of a salt such as lithium hexafluorophosphate dissolved in an organic solvent consisting of two or more aprotic constituents, one of which may be propylene carbonate as well as a positive electrode such as a lithium metal oxide. Propylene carbonate (PC) based solvents normally cause exfoliation of a graphite negative electrode resulting in the degradation of its electrochemical properties. Propylene carbonate, however, is an excellent solvent for use in lithium ion cells in that it permits cell operation to cross a broad temperature range with graphite based negative electrodes, which provide excellent power characteristics.

Non-aqueous rechargeable lithium batteries can be made safe against thermal runaway by incorporating small amounts of suitable additive materials into the electrolyte. Flame retardant additives maybe selected from a blend of organic phosphates and carbonate compounds, such as triphenyl phosphate and aryl/alkylphosphate, and vinyl ethylene carbonate or from single additives can provide superior thermal safety behavior at the fully charged state in high voltage lithium ion batteries. Some of these compounds can also be used as degassing additives in lithium rechargeable batteries by preventing gas generation at extremely high temperature storage. Preferably, these additive compounds are soluble in the electrolyte.

Propylene carbonate based solvents can be utilized in lithium ion batteries provided that an additive is used in the electrolyte which forms a surface coating on the graphite particles of the negative electrode (anode) that prevents the propylene carbonate solvent from entering the crystal lattice of the graphite thereby preventing exfoliation of the graphite material with the resulting degradation of its electrochemical properties as a negative electrode. Anode passivating materials such as vinyl ethylene carbonate, vinyl quinone, vinylcrotonate and derivatives thereof, 9-fluorenone, vinyl acetate, vinylimidazole, tribally triazine trione, 4,5-diethenyl-1,3-dioxolan-2-one, 4-ethenyl benzene-1,3-dioxolan-2-one, methyl silyl carbonate, 1,5-hexene-2,3-carbonate, 4-methyl-4-silyl-1,3-dioxolan-2-one, 4,5-diphenyl- 1,3-dioxolan-2-one, 4,4-diphenyl-1,3-dioxolan-2-one, vinyl ethylene sulfite, 4-methoxymethyl-1,3-dioxolan-2-one, 4-

hydroxymethyl-1,3-dioxolan-2-one, 4-(1-propenoxymethyl)-1,3-dioxolan-2-one, 4-(2-propenyl)-1,3-dioxolan-2-one, ethyl-2-furoate, 4-ethenol-1,3-dioxolan-2-one, 2-methoxyl-1,3-dioxolan may be used to passivate the anode or negative electrode and also prevent gassing, extend the calendar and cycle life of the battery and assist in improving the safety of the battery or cell. These later named additives also have the added property of preventing exfoliation of graphite containing anodes in the presence of propylene carbonate.

Figures 2(a)-(c) (Exhibit A) compares the heat flow from a reaction between fully charged graphite anode, and electrolyte $\text{LiPF}_6/\text{EC}/\text{DEC}$ with vinyl ethylene carbonate (Fig. 2A), with triphenyl phosphate (Fig. 2B), and with mixture of 2 wt. % VEC, 2 wt% TPP and 1 wt% MDP (Fig. 2C) flame retardant. The electrolyte containing flame retardant appears to have significantly better thermal behavior though the concentration of the flame retardant used in the electrolyte is less than 5 wt%. The addition of 2 wt% VEC, 2 wt% TPP and 1 wt% MDP mixed additive (Fig. 2C) significantly improves the safety performance of the cell. In this case, the onset temperature of reaction increases from 130°C in the cell without additive to 210°C in the cell with a mixed additive of 2-wt% VEC, 2 wt% TPP and 1 wt% MDP. In addition, the heat flow is an order of magnitude lower in the cell with a mixed additive 2 wt% VEC, 2 wt% TPP and 1 wt% MDP than in the cell without additive. Furthermore, adding only 5% VEC or 5% TPP slightly improves the safety performance of the cell by increasing the onset temperature to 160°C and 190C in VEC and TPP, respectively. However, the amount

of heat flow although reduced is still significantly higher than in the case of adding a mix of 2 wt% VEC, 2 wt% TPP and 1 wt% MDP

Overcharge studies of the 180 mAh Li-ion cell indicate that when a mixture of 2 wt % vinyl ethylene carbonate, 2 wt % triphenyl phosphate, and 1 wt % monophenyl-dibutyl phosphate (MDP) are added to the electrolytes, the normal pressure build up in the cell caused by gassing is reduced by a factor of ten, going from 20% to < 2% in

Table 1:

Table 1. Cell body thickness change after oven test

Added Flame Retardant Composition	Cell Volume Change After Over Charge Test (%)
5 % VEC	19
5 % TPP	16.8
2% MDP+2%VEC+1%TPP	2.9

As shown in Figs. 3(A) and 3(B) (Exhibit B), safety studies of the prismatic Li-ion cell indicate that when a mixture of 2 wt % vinyl ethylene carbonate, 2 wt % triphenyl phosphates, and 1 wt % monophenyl-dibutyl phosphate are added to the electrolytes, there was no thermal runaway at high temperature storage of 150°C after oven test, and even nail penetration test. The oven test was carried out in a cell that was initial over discharged to 4.5V and then stored at 150°C for two hours in an oven. The cell temperature was monitored during the storage time. The nail penetration test was carried on a cell that was overcharged to 4.5V. The additive mixture was thus found to significantly enhance the Li-ion battery safety, reduce gassing in the cell and had no negative effects on the normal capacity or cycle life.

The invention also includes various additives which added to the electrolyte passivate the anode , suppress gassing during cycling, extends calendar life and improves the safety of the lithium batteries. Particularly, but not exclusively, in a situation where the electrolyte consists of a salt such as lithium hexafluorophosphate dissolved in organic solvent consisting of two or more aprotic constituents, one of which is propylene carbonate, the various additives hereinafter set forth prevent the graphite anodes, when present, from exfoliating in the presence of propylene carbonate. Propylene carbonate is a desirable electrolyte solvent because it provides a solvent with a high dielectric constant permitting the dissolution of the fluoride salt to form a highly conductive electrolyte across a broad temperature range. Passivating material used with graphite containing anodes prevents the propylene carbonate solvent from entering the crystal lattice of the graphite, which ruins its electrochemical properties as a negative electrode. Being able to use the propylene carbonate based solvents in lithium ion cells has a huge advantage in that it permits cell operation across a broad temperature range with a graphite based negative electrode that possesses excellent power characteristics. Propylene carbonate is of low cost and provides a very stable electrolyte, which prolongs the calendar life and improves the safety of the lithium ion system.

Additives which are capable of passivating anodes and where the anode includes graphite preventing exfoliation of the graphite in the presence of propylene carbonate include vinyl ethylene carbonate, vinyl quinone, vinylcrotonate, 9-fluorenone,

vinyl acetate, tribally triazine trione, 4,5-diethenyl-1,3-dioxolan-2-one, 4-ethenyl benzene-1,3-dioxolan-2-one, methyl silyl carbonate, 1,5-hexene-2,3-carbonate, 4-methyl-4-silyl-1,3-dioxolan-2-one, 4,5-diphenyl- 1,3-dioxolan-2-one, 4,4-diphenyl-1,3-dioxolan-2-one, vinyl ethylene sulfite, 4-methoxymethyl-1,3-dioxolan-2-one, 4-hydroxymethyl-1,3-dioxolan-2-one, 4-(1-propenoxymethyl)-1,3-dioxolan-2-one, 4-(2-propenyl)-1,3-dioxolan-2-one, ethyl-2-furoate, 4-ethenyl-1,3-dioxolan-2-one, 2-methoxyl-1,3-dioxolan, divinylphenyl carbonate, dicarbonate quinione, ec hydrazine, bis-N,N-dimethylcarbamate, 4,4-dimethyl-5-methylene-1,3-dioxolan-2-one, benzene tetracarboxyldianhydride, 4-methoxyphenyl-1,3-dioxolan-2-one, 4-trifluorobenzyl-1,3-dioxolan-2-one.

VI. GROUND S OF REJECTION TO BE CONSIDERED ON APPEAL

1. Whether the Examiner is correct in finally rejecting and not allowing claims 1, 2, 22, 29, 31 and 32 under 35 U.S.C. § 103(a) as being unpatentable over Olsen et al. U.S. Patent No. 5,455,127, in view of Kotado et al. JP 2001-0067629.

2. Whether the Examiner erred in finally rejecting and not allowing claims 1, 3-8, 11, 15, 23, 28, 30-32 under 35 U.S.C. § 103(a) as being unpatentable over Gan et al. U.S. Patent No. 6,068,950, in view of Kotado et al. JP 2001-006729.

3. Whether the Examiner erred in finally rejecting and not allowing claims 14 and 16-17 under 35 U.S.C. § 103(a) as being unpatentable over Gan et al. U.S. Patent No. 6,068,950 in view of Kotado et al. JP 2001-006729 as applied to claim 1, and further in view of Tobishima JP 358214281. The Examiner's attention is drawn to the

discrepancy of citations against the rejection of claims 14 and 16-17. The Sekino et al. Publication No. 2002/0164531 is listed and cited on page 3 and the Tobishima reference JP 358214281 is listed and cited on page 7 of the Final Office Action.

4. Whether the Examiner erred in finally rejecting and not allowing claims 12 and 18-21 under 35 U.S.C. § 103(a) as being unpatentable over Olsen et al. U.S. Patent No. 5,455,127 in view of Kotado et al. JP 2001-006729 as applied to claim 1, in view of McMillan et al. U.S. Patent No. 6,506,524.

5. Whether the Examiner erred in finally rejecting and not allowing claim 26 under 35 U.S.C. § 103(a) as being unpatentable over Gan et al. U.S. Patent No. 6,068,950 in view of Kotado et al. JP 2001-006729 as applied to claim 1, and further in view of Tobishima JP 358214281.

VII. **ARGUMENT**

The Examiner in rejecting claims 1, 2, 22, 29, 31 and 32 as being unpatentable over the Olsen et al. '127 patent in view of the Kotado et al. JP 2001-006729 reference has made a fundamental mistake in her rejection in two specific instances, the first being in failing to recognize that the combination of materials taught in the subject application and claimed provide unexpected results which must be considered by the Examiner, see *In re Soni* 35 U.S.P.Q. 2d1684 (Fed. Cir. 1995) and second being that the mere fact that various aspects of the invention are available in the prior art does not permit the Examiner to use the applicants own teaching in a hindsight reconstruction of the invention without some independent teaching or suggestion in the prior art that the

individual components should be combined as suggested by the Examiner, In re Brouwer, 37 U.S.P.Q. 2d 1663 (Fed. Cir. 1996); In re Chu, 36 U.S.P.Q. 2d 1089 (Fed. Cir. 1995); In re Dillon, 16 U.S.P.Q. 2d 1897 (Fed. Cir. 1990); In Re Fine, 5 U.S.P.Q. 2d 1596 (Fed. Cir. 1988); Ex Parte Metcalf, 67 U.S.P.Q. 2d 1633 (Bd. Pat. Appl. & Inter. 2000).

Reference to Exhibits A and B illustrate that the claimed combination of materials provides results which are significantly superior to results of the individual components and would not be obvious to one of ordinary skill in the art. Moreover, the results reported in Table 1 reproduced above clearly show that the three materials together result in a cell volume change after overcharge of only 2.9% for the three additives compared to 19% per VEC alone and 16.8% for TPP alone. Clearly, none of these results could have been predicted by one of ordinary skill in the art so that it is clear that the combination of additives provide a synergy that cannot be assumed to be predictable from viewing the prior art without incorporating the applicants' teaching. The results herein reported are unexpected and significant. Accordingly, under the foregoing cases cited both in the Federal Circuit and in the Board of Appeals (it is recognized that the Board decision is non- precedential) , the Examiner must consider the evidence in the record (the patent application) and cannot use the applicants' teaching as an impetus for combining various aspects of the prior art in a manner nowhere suggested other than in the subject application.

The Examiner has admitted that the Olsen '127 reference is silent as to anode passivation such as with vinyl ethylene carbonate and it is nowhere suggested that the Olsen '127 reference could be combined in the manner suggested by the Examiner. For instance, the reason given in the subject application for using the vinyl ethylene carbonate is to prevent the degradation of a graphite negative electrode when using propylene carbonate as a solvent, see the description of the invention above, whereas the Olsen et al. '127 reference does not relate to a cell using the crystalline graphite negative electrode. Absent the use of the graphite electrode as taught in the subject invention, there is no reason to combine the Japanese reference with the Olsen et al. '127 reference. The Examiner is simply using pieces of the prior art without any suggestion or teaching to combine, as prohibited by the Federal Circuit and the Board of Appeals, see *In re Chu*, and *In re Fine*, supra. Moreover, the Examiner has not given sufficient consideration to the evidence of unexpected results contained in the application, as required by the Federal Circuit in *In re Soni*, supra.

For all the foregoing reasons, it is respectfully suggested that the Examiner erred in finally rejecting and not allowing claims 1, 2, 22, 29, 31 and 32 and these claims should be allowed.

The Examiner rejected claims 1, 3-8, 11, 15, 23, 28, 30, 31 and 32 under 35 U.S.C. §103(a) as being unpatentable over the Gan et al. U.S. patent no. 6,068,950 in view of Kotado et al. JP 2001-006729 reference.

The Gan '950 patent teaches the use of organic phosphate additives to avoid voltage delays in cell operation but does not relate to the safety of the Li-ion battery during overcharge and contains no references to the vinyl ethylene carbonate (VEC). It is clear from the gassing data in Table I of the present application and the arc data of Fig. 2B (Exhibit A) of the application that triphenyl phosphate, a typical additive, cited by Gan is not very effective as a safety additive at the elevated temperatures encountered during battery overcharge and abuse. This simply means that the passivation film formed on the surface of the anode by the additives at room temperature are unstable at elevated temperatures encountered during battery overcharge and abuse. This suggests that the passivation film is probably partially dissolved in the electrolyte, since the gassing characteristics of battery are still very high.

The Kotado Japanese patent clearly indicates, as the Patent Examiner suggested, that vinyl ethylene carbonate is effective in stabilizing the anode in the presence of propylene carbonate and other organic carbonate based electrolytes at room temperature. However, the inventors' experiments show (Table I) the gassing characteristics during the Li-ion battery overcharge seems to be effected very little by the presence of a 5 w/o additive of vinyl ethylene carbonate. Moreover, the Arc data (Fig. 2-A) (Exhibit A) show that this additive has the worse performance at elevated temperature during cell abuse. The onset temperature of reaction is very low which means that the cell stability is lost in the very early stages of the abuse process. Again, suggesting that during over charge and cell abuse at high temperature, the elevated

temperature causes the passivation film on the anode to breakdown probably by dissolution in the electrolyte. The VEC additive is well known to form a passivation film at the carbon anode to improve the cycling performance of the cell at room temperature; however, this passivation film tends to breakdown at temperatures higher than 60°C. Therefore, when one blends organic phosphates and vinyl ethylene carbonate, see Table I of the patent application and (Fig 2-C) (Exhibit A), it is not at all obvious that one-skilled-in-the-art would predict that the free radicals formed by the vinyl ethylene carbonate would interact with the organic phosphates to significantly reduce the battery gas generation by an order of magnitude and improve the abuse tolerance of the cell at high temperature by an order of magnitude. These results are unexpected and cannot be said to be obvious to one of ordinary skill in the art.

Cell gassing and heat generation are both critical items that need to be addressed in developing improved battery safety. In both of these critical areas the proposed blend of additives in Table I and Figs. 2-C (Exhibit A) of the application shows marked improvement over any single additive. A scientist of ordinary skill in this art who looks at the effect of the single additives would predict that a blend of the additives would probably result in a cell volume change of 16 % and not the 2.9 % observed. Another factor in support of this invention is the fact that there are no references on the effect of the proposed additive blends as they relate to Li-ion battery gassing and safety. During Li-ion battery overcharge, it is quite obvious from the inventors'

experiments that one could not predict how the blend of additives will function knowing how the respective individual additives function. It is important for the Examiner to understand that it is entirely possible to improve the stability and cycle life of the Li-ion battery at room temperature through the use of an additive that prevents surface reaction but which causes power and capacity fade. However, these same additives may not be effective at higher temperatures because the passivation films formed by them breakdown. This has been shown time and time again in efforts at Argonne National Laboratory, to stabilize various Li-ion battery couples at elevated temperatures.

Accordingly, under the law cited above the Examiner in failing to account for the evidence of unexpected results set forth in the application, as previously discussed, and applying hindsight in the combination of references without any suggestion or teaching that it would be desirable to do so, has incorrectly rejected claims 1,3-8, 11, 15, 23, 28, 30, 31 and 32 and it is suggested that these claims should be allowed.

Claims 14 and 16-17 were rejected under 35 U.S.C. §103(a) as being unpatentable over the Gan '950 patent in view of the Kotado et al. Japanese reference and further in view of the Tobishima Japanese reference JP 358214281.

The addition of the references suggested by the Examiner, does not add anything significant to the Examiner's rejection as there is no suggestion or teaching of the type required in any of the additional references. The suggested cathode in the Gan et al. '950 patent covers a very large number of materials, see column 4, lines 23-

38 and even if it can be construed to include the graphite electrode of the subject invention, it is a situation where the Examiner has cherry picked various combinations of hundreds of thousands of possible combinations in order to replicate the invention without any real teaching that it is desirable to do so or any suggestion that the unexpected results of the subject invention would occur. For those reasons, it is respectfully suggested that the Examiner is entirely in error in the rejection of the claims 14, 16 and 17 and these claims should be allowed.

Claims 12 and 18-21 were rejected under 35 U.S.C. §103(a) as being unpatentable over Olsen et al. '127 patent in view of the Kotado et al. JP 1001-006729 reference in view of the McMillan et al. U.S. Patent No. 6,506,524.

The flawed reasoning cited above is again repeated by the Examiner in this rejection and accordingly it is suggested that claims 2 and 18-21 are patentable and should be allowed.

Claim 26 was rejected under 35 U.S.C. §103(a) as being unpatentable over the Gan et al. '950 patent in view of the Kotado et al. Japanese reference 2001-006729 in view of the Tobishima JP 358214281 reference.

For all the foregoing reasons, none of which bear here repeating, the Examiner is incorrect in her rejection and claim 26 should be allowed.

Finally, in the final rejection, the Examiner has attempted to categorize the arguments regarding unexpected results as mere lawyers arguments and suggested that the applicants must submit an Affidavit or Declaration to establish the results.

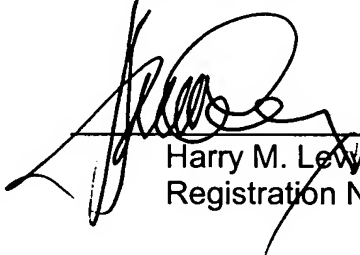
However, the Examiner's citation to *In re Schulze*, 346 F.2d 600, 602, 145 USPQ 716, 718 (CCPA 1965) is erroneous. The specification is the same as a sworn statement and the evidence in the specification in the Tables and Figures cannot be ignored as this Examiner has done, see *In re Soni*, supra. The Examiner's rote citation of CCPA cases from long ago are simply no substitute for analyzing this particular case, the specification and the drawings, all of which reflect actual experiments and scientifically provided data. It is simply insufficient for the Examiner to categorize the evidence in the specification as lawyers arguments and it is respectfully suggested that the Board reverse the Examiner and allow all of the claims on appeal.

Three copies of this Brief including Appendices are enclosed herewith along with the filing fee in the amount of \$ 250.00.

A Petition for one-month extension of time and fee are also enclosed.

Dated: 2/6/05

Respectfully submitted,
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VIII. CLAIMS APPENDIX

1. A non-aqueous rechargeable lithium battery having a lithium insertion compound positive electrode, a negative electrode of one or more of lithium, lithium compound, and carbon, a solvent for a non-aqueous electrolyte containing a lithium salt and a blend of flame retardants and anode passivation additives, and gassing suppression additives, said flame retardant additive selected from one or more of aryl/alkyl phosphate, such as a triphenyl phosphate, $(C_6H_5)_3PO_4$, a diphenyl monobutylphosphate, (DMP) $C_4H_9(C_6H_5)_2PO_4$, and a phenyl alkyl phosphate, $(C_6H_5)R_2PO_4$, a cyclic ethyl carbonate, $C_2H_4CO_3$, and derivatives thereof, where the 1 to 4 hydrogen groups are replaced with a C1-C6 alkane, a fluoridated C1-C6 alkane, an unsaturated alkane carbonate and a mixtures thereof, and said anode passivation material being one or more of the following: vinyl ethylene carbonate vinyl quinone, vinylcrotonate, 9-fluorenone, vinyl acetate, tribally triazine trione, 4,5-diethenyl-1,3-dioxolan-2-one, 4-ethenyl benzene-1,3-dioxolan-2-one, methyl silyl carbonate, 1,5-hexene-2,3-carbonate, 4-methyl-4-silyl-1,3-dioxolan-2-one, 4,5-diphenyl- 1,3-dioxolan-2-one, 4,4-diphenyl-1,3-dioxolan-2-one, vinyl ethylene sulfite, 4-methoxymethyl-1,3-dioxolan-2-one, 4-hydroxymethyl-1,3-dioxolan-2-one, 4-(1-propenoxymethyl)-1,3-dioxolan-2-one, 4-(2-propenyl)-1,3-dioxolan-2-one, ethyl-2-furoate, 4-ethenol-1,3-dioxolan-2-one, 2-methoxyl-1,3-dioxolan, divinylphenyl carbonate, dicarbonate quinione, ec hydrazine, bis-N,N-dimethylcarbamate, 4,4-dimethyl-5-methylene-1,3-dioxolan-2-one, benzene tetracarboxyldianhydride, 4-methoxyphenyl-1,3-dioxolan-2-

one, 4-trifluorobenzyl-1,3-dioxolan-2-one.

2. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is one of the following or combination thereof: vinylcrotonate, 9-fluorenone, vinyl acetate, tribally triazine trione, 4,5-diethenyl-1,3-dioxolan-2-one, 4-ethenyl benzene-1,3-dioxolan-2-one, methyl silyl carbonate, 1,5-hexene-2,3-carbonate, 4-methyl-4-silyl-1,3-dioxolan-2-one, 4,5-diphenyl-1,3-dioxolan-2-one, 4,4-diphenyl-1,3-dioxolan-2-one, vinyl ethylene sulfite, 4-methoxymethyl-1,3-dioxolan-2-one, 4-hydroxymethyl-1,3-dioxolan-2-one, 4-(1-propenoxymethyl)-1,3-dioxolan-2-one, 4-(2-propenyl)-1,3-dioxolan-2-one, ethyl-2-furoate, 4-ethenol-1,3-dioxolan-2-one, 2-methoxyl-1,3-dioxolan, divinylphenyl carbonate, dicarbonate quinone, ec hydrazine, bis-N,N-dimethylcarbamate, 4,4-dimethyl-5-methylene-1,3-dioxolan-2-one, benzene tetracarboxyldianhydride, 4-methoxyphenyl-1,3-dioxolan-2-one, 4-trifluorobenzyl-1,3-dioxolan-2-one.

3. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of monobutyl-diphenyl phosphate, dibutyl-monophenyl phosphate and vinyl ethylene carbonate.

4. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of monopropyl-diphenyl phosphate, dipropyl-monophenyl phosphate and vinyl ethylene carbonate.

5. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of triphenyl phosphate, vinyl ethylene carbonate and dibutyl-monophenyl phosphate.

6. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of monobutyl-diphenyl phosphate and diamyl-monophenyl phosphate and vinyl ethylene carbonate.

7. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is monobutyl-diphenyl phosphate and vinyl ethylene carbonate.

8. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is dibutyl-monophenyl phosphate and vinyl ethylene carbonate.

11. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of triphenyl phosphate and vinyl ethylene carbonate, present up to about 3-wt% of the electrolyte.

12. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of monofluoroethylene carbonate and triphenyl phosphate, each present up to about 3 wt% of the electrolyte.

13. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is vinyl ethylene carbonate and tributyl phosphate and a fluoridated hexane.

14. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is monoamyl-diphenyl phosphate, and vinyl ethylene sulfite

15. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of triphenyl phosphate, monoamyl-diphenyl phosphate and vinyl ethylene carbonate.

16. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is monophenyl ethylene carbonate and monophenyl dibutyl phosphate.
17. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of monophenyl carbonate and triphenyl phosphate.
18. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of 1,2-difluoroethylene carbonate and triphenyl phosphate.
19. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of 1,2-difluoroethylene carbonate, triphenyl phosphate and monobutyl-diphenyl phosphate.
20. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is monofluorovinyl ethylene carbonate, and tripropyl phosphate.
21. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the additive is a mixture of monofluorovinyl ethylene carbonate and triphenyl phosphate.
22. A non-aqueous rechargeable lithium battery as in Claim 1, wherein the total concentration of additive is between 0.01 wt% and 20wt% by weight of the electrolyte.
23. A non-aqueous rechargeable lithium battery as in Claim 1, in which said additive is vinyl ethylene carbonate and tributyl phosphate.
26. A non-aqueous rechargeable lithium battery as in Claim 1, in which said additive is a mixture of 9-fluorenone, and tripropyl phosphate.
27. A non-aqueous rechargeable lithium battery as in Claim 1, in which said compound is vinylimidazole.

28. A non-aqueous rechargeable lithium battery as in Claim 1, in which said additive is N-vinyl-2 pyrrolidinone and triphenyl phosphate.

29. A non-aqueous rechargeable lithium battery as in Claim 2, in which said compound is added in a proportion of 0.001% to 20% by weight of said electrolyte.

30. A non-aqueous rechargeable lithium battery as in Claim 1, in which the solvent includes propylene carbonate and one or more solvents selected from ethylene carbonate, dimethyl carbonate, ethyl methyl carbonate or similar organic carbonate solvents.

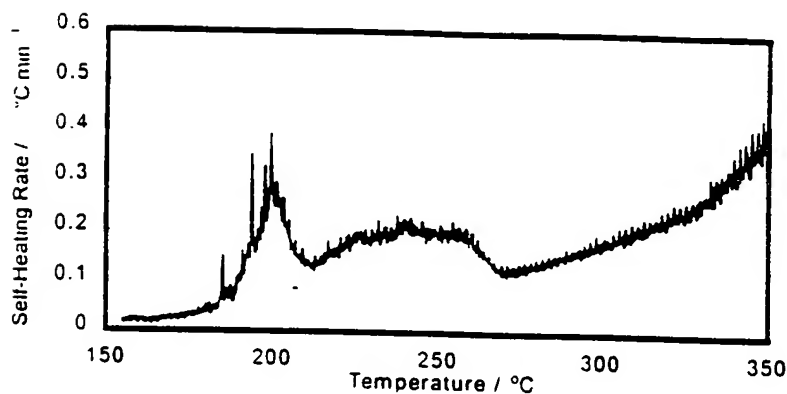
31. A non-aqueous rechargeable lithium battery as in Claim 1, in which said lithium salt is selected from lithium hexafluorophosphate, lithium tetrafluoroborate, lithium hexafluoroarsenate lithium perchlorate or amide salt.

32. A non-aqueous rechargeable lithium battery as in Claim 1, in which said positive electrode is selected from an oxide or phosphate of lithium metal or manganese, nickel, cobalt and iron, or a combination thereof.

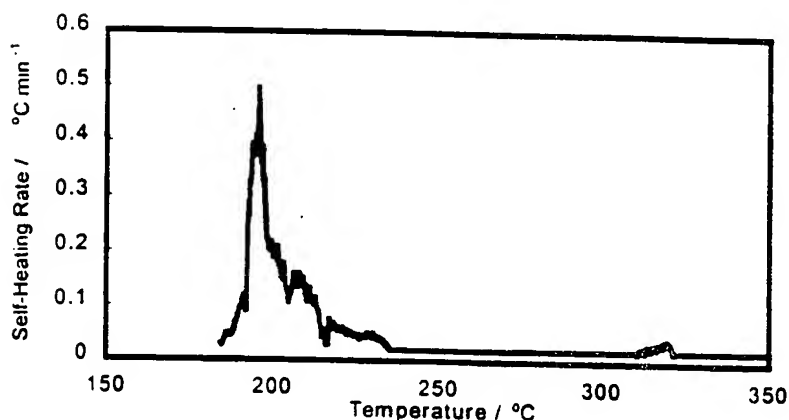
IX. EVIDENCE APPENDIX

Appendix A - Figures 2(a)-(c)

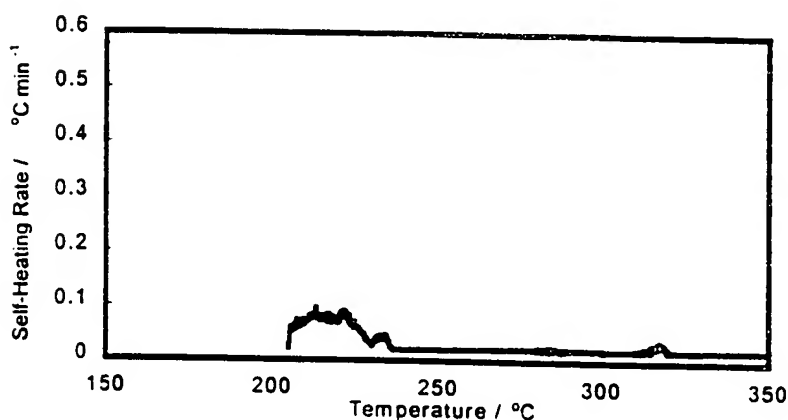
Appendix B Figs. 3(A) and 3(B)



(A) with 5 wt% VEC

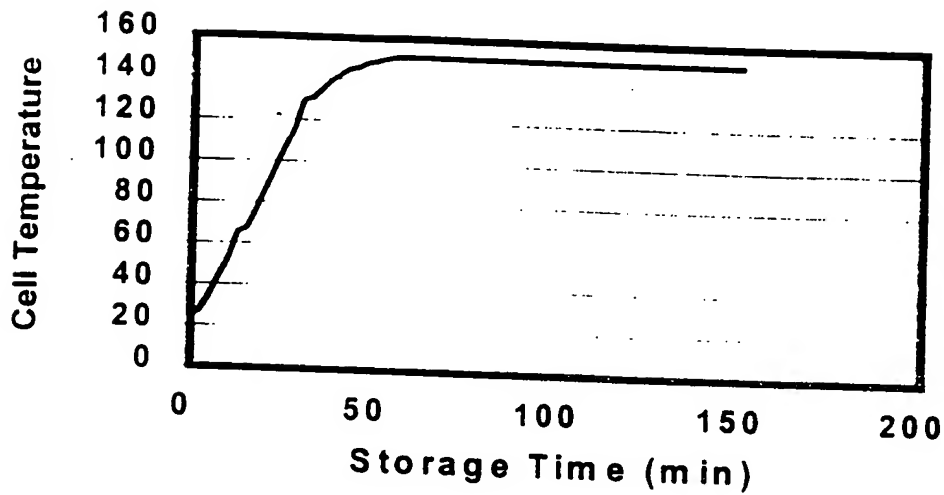


(B) with 5 wt% TPP

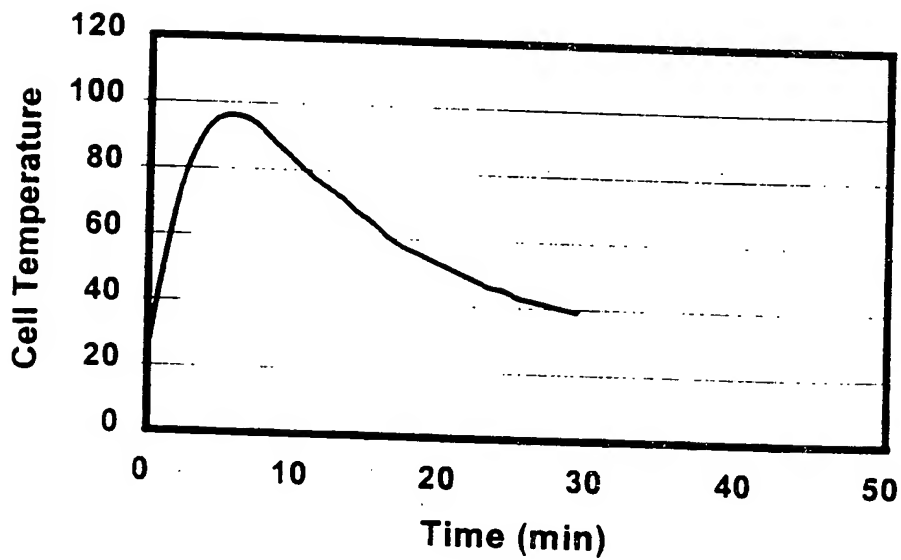


(C) with mixture of 2 wt% VEC, 2 wt% TPP, and 1 wt% MDP

Fig.2. Self Heat rate from ARC experiment of the reaction between fully charged graphite anode and $\text{LiPF}_6/\text{EC}/\text{DEC}$ electrolyte with 5 wt% VEC (Fig.2A), with 5 wt% TPP (Fig.2B) and with 2 wt% VEC + 2 wt% TPP + 1 wt% DMP mixture (Fig.2C) flame retardant.



(A) Oven test



(B) Nail penetration test

Fig.3. Oven test (Fig.3A) and nail penetration test (Fig.3B) of 180 mAh prismatic cells containing mixture of 2 wt% VEC, 2 wt% TPP, and 1 wt% MDP as flame retardant.



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X. RELATED PROCEEDINGS APPENDIX

There are no related appeals and interferences.